

## Appendix 3. The North Hanley Light Rail Corridor Serving St. Louis

### Executive Summary

Working Paper 1 (Subtask 1d, November 25, 1998) develops a theoretical and measurement framework within which the Mogridge-Lewis Convergence Hypothesis (MLC) can be employed in measuring the savings in highway delay attributable to transit and its equilibrating effect on the level of service in the corridor.

The framework also provides an MLC-based approach to making repeated measures of transit-induced savings in corridor delay without the need for repeated MLC surveys. The approach rests on the theoretical proposition, proven in Working Paper 1, that a stable and measurable relationship exists between roadway traffic growth over time and the inter-modal (highway-transit) equilibrium dynamics that give rise to delay savings in a congested corridor. In the absence of major changes in the level of highway supply or transit service in the corridor, this measured relationship, or model, provides a formula-based performance measurement system in lieu of a survey-based approach. In addition to the obvious cost advantages, this approach provides FTA with (i) an efficient means of measuring and comparing transit performance in strategic corridors; and (ii) a consistent performance assessment tool for transfer to MPOs throughout the country.

### *Purpose and Method*

This Working Paper presents a case study of the methodology developed in Subtask 1c in application to the North Hanley – St. Louis corridor (the Metro Link light rail system). The methodology consists of calibrating the MLC-traffic model with

N.Hanley-St. Louis survey data. The model is then used to quantify delay savings

attributable to Metro Link at present, and at alternative roadway traffic volumes (each for different user categories).

The study consists of four main steps:

1. Collecting highway travel data (traffic volume, distance, travel time, and vehicle occupancy in the corridor); and light rail ridership data along the corridor;
2. Conducting door-to-door travel time surveys and deriving the inter-modal convergence;
3. Estimating the “with transit” and “without transit” model and related curves and estimating the hours of delay saved due to transit; and
4. Quantifying delay savings by user category, namely, (i) light rail riders (“market” benefits); (ii) common segment users (“club” benefits); and, (iii) parallel highway users (“spillover” benefits).

The N. Hanley-St. Louis corridor was selected to measure the performance of the Metro Link light rail system connecting several residential areas with the Central Business District of St. Louis, Missouri. MLC theory predicts that the improved transit system will attract modal explorers, reduce congestion, and improve roadway travel times. As a result, we would expect to see improvements in both highway and transit door-to-door travel times

### *Principal Findings*

The case study finds that based on the MLC model calibrated with 1999 survey data, the magnitude of peak-period delay savings per trip due to transit is about 3.89 minutes per door-to-door journey (Table A

3.1). These savings amount to about 11 percent of total door-to-door journey times and align with reasoned expectations.

HLB estimated the hours of delay savings for three different user groups: Metro riders (market benefits), users of the I-70 common segment (club benefits), and users of parallel highways (spillover benefits). Table A 3.4 also presents the estimated delay savings by category of user. Based on an assumed value of peak travel time of \$15 per hour and an average of 250 working days per year, Table A 3.1 through Table A 3.3 show the benefits estimate by user category.

**Table A 3.1 Daily Club Benefits**

	Distance (miles)	Traffic Volume	Savings (hours)
Common Segment			
I-70	11	61,167	1,826
Access Segment			
( average)	2.5	37,000	251
Total	13.50		2,077

Table A 3.4 shows that the 1998 delay saving attributed to transit on the N.Hanley-St. Louis corridor is estimated at about \$22.7 million. This can be translated to \$1.7 million per rail mile.

These findings are surprisingly very similar to the ones found in the case study of the Gateway-Portland corridor. Although an intermodal travel time convergence of 11 minutes is sufficient to yield delay savings to highway users (as compared to the “without rail” case), full convergence would of course yield even greater savings.

Also, similar to the findings in Gateway-Portland Corridor, St. Louis’s current parking structure in stations such as North Hanley Station (“horizontal” rather than “vertical” park-and-ride expansion) is not consistent with the maximization of transit’s

performance as a “regulator” of multi-modal corridor performance.

**Table A 3.2 Daily Market Benefits**

Station	West-bound Trips	East-bound Trips	Savings (hours)
N. Hanley	312	2,635	114.64
UMSL			
North	111	829	34.74
UMSL			
South	239	1,233	51.53
St. Charles			
Rock Road	482	1,207	55.85
Wellston	386	869	39.06
Delmar			
Blvd.	729	1,487	64.65
Forest Park	664	1,413	56.56
Central			
West End	1,907	1,539	87.13
Grand			
Avenue	1,680	1,080	64.42
Union			
Station	1,539	1,294	60.61
Kiel Center	828	385	21.23
Bush			
Stadium	603	355	14.91
8 <sup>th</sup> and Pine	1,468	918	37.13
Convention			
Center	1,595	1,509	42.26
Total			745

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**Table A 3.3 Daily Spillover Benefits**

Highways in the corridor:	Distance (miles)	Traffic Volume	Savings (hours)
W. Florissant Blvd.	5.95	19,000	276.07
Natural Bridge	7	22,800	389.75
Saint Louis Blvd.	3.85	12,650	92.50
Dr. Martin Luther King Blvd.	7	28,640	462.38
Delmar Blvd.	4.2	18,000	143.59
Page Street	5.95	16,040	181.27
College Lane/Lindell Boulevard	3.15	18,760	112.24
Forest Park Avenue	3.85	22,480	164.39
I-64/I-170	13.3	62,019	1,454.80
Total			3,277

**Table A 3.4 Summary of Network Benefits**

Benefit Category	Daily Savings		Yearly Savings
	In Hours	In Dollars	In Dollars
Market	701	\$ 10,519	\$ 2,629,762
Club	2,077	\$ 31,150	\$ 7,787,481
Spillover	3,277	\$ 49,155	\$ 12,288,780
Total	6,055	\$ 90,824	\$ 22,706,023



**Figure A 3.1 North Hanley Metro Link Station**



**Figure A 3.2 Convention Center Metro Link Station**

## Introduction

This report presents the results of the North Hanley – St. Louis corridor case study as part of Streamlined Strategic Corridor Travel Time Management study. The purpose of the study is to use the convergence measurement technique to derive a repeatable performance measurement for rail transit in congested corridors. This case study measures the performance of St. Louis’ light rail system—known as Metro Link—using the methodology developed in Subtask 1c. The methodology consists of calibrating the Mogridge-Lewis Convergence Hypothesis (MLC) model with survey data and using the model to quantify delay savings attributable to transit at different roadway traffic volumes. The savings are estimated for three different user categories using highway traffic and light rail ridership data in this corridor.

### *Study Methodology*

The study methodology consists of four main steps:

1. Collecting highway travel data (traffic volume, distance, travel time, and vehicle occupancy in the corridor), and light rail ridership data along the corridor;
2. Conducting door-to-door travel time surveys and deriving the inter-modal convergence;
3. Estimating the “with transit” and “without transit” model and related curves and estimating the hours of delay saved due to transit; and
4. Quantifying delay savings by user category, namely, (i) light rail riders (“market” benefits); (ii) common segment users (“club” benefits); and, (iii) parallel highway users (“spillover” benefits).

During the first step, HLB collected HPMS data, local arterials traffic data, and light rail ridership data from Bi-State Development Agency (the local transit authority), East-West Gateway Coordinating Council (the local MPO) and Missouri Department of Transportation. The data were used to estimate the model parameters.

For the second step, data were collected on the North Hanley - St. Louis corridor by a survey team. A corridor, as defined in this study, is a principal transportation artery into the central business district. Multiple transportation services are available to commuters who use this artery. Additionally, during the peak period a large number of commuters utilize this route in their door-to-door commute.

A statistical sample of trips was generated in the corridor by identifying random trip end point in the zones at either end of the corridor and joining them so that trips alternated between zones. These zones are catchment zones where travelers converge or diverge from either the transit station or the principal highway route. For this study these zones are defined as the access segment and the component of the corridor common to all trips for a given mode, regardless of trip end location, is defined as the common segment.

Survey crews were instructed to follow specific routes consisting of an access segment—dependent on the catchment zone considered for the trip—and a common

segment. The data collected include start and arrival times for each segment, by mode of transportation, congestion level, seating availability, weather, road conditions, and travel costs for each segment.

Data were collected over a period of three consecutive days (Tuesday to Thursday) during the first week of March 1999. The days of the week were sampled to eliminate fluctuations in traffic patterns and volumes due to the day of week effects. Trips were validated to minimize the effects of unusual or circumstantial conditions. Sixty valid trips were selected to ensure a statistically adequate sample size. The study employed routes connecting several zones within a residential area to several points within St. Louis's central business district.

Step three consisted of estimating the "with transit" curve based on the traffic volume and the door to door travel time. Using the model developed in Subtask 1c, HLB derived the "without transit" curve and estimated the hours of delay saved due to transit. This performance metric is defined as the vertical difference between the two curves.

In step four, the hours of delay saved due to transit are aggregated into three user categories. Savings by common highway-segment users are estimated using the traffic volume on the segment. Savings by light rail riders are estimated using the ridership data for each station along the corridor. Savings by parallel highway users are estimated using traffic volume on parallel highways and arterials within the corridor. The magnitude of the savings decreases as the distance between the common segment and the parallel highway increases.

### *Plan of the Report*

This report presents the results from the North Hanley -St. Louis corridor case study. Following this introduction, the first section presents an overview of the model and methodology to estimate the delay saving. It is followed by a discussion of the corridor characteristics and a description of the principal modes of transportation within the corridor. Then, we present the results from the 1999 door-to-door travel survey and the model estimation. This includes the hours of delay saved due to transit per person, per day; and the monetary value of the delay saved for the three user categories. Annexes provide maps of the residential area and the central business district as well as supporting data and supplementary route level results.

### **Methodology and Model Overview**

The methodology consists of four steps:

1. Estimating the Corridor Performance Baseline
2. Estimating the Corridor Performance in the Absence of transit
3. Extrapolating Delay Savings Due to Transit
4. Estimation of Corridor Performance without Re-calibration

*Estimating the Corridor Performance Baseline*

The Model This model establishes a functional relationship between the person trip volume—all modes—and the average door to door travel time by auto in the corridor.

The door to door travel time by auto can be determined using a logistic function which calculates the door to door travel time in terms of travel time at free flow speed, trip time by high capacity rail mode, and the volume of trips in the corridor for all modes. The door to door travel time can be estimated as follows:

$$T = (T_c - T_{ff}) / (1 + e^{-(\delta + \epsilon V)}) + T_{ff} \quad (1)$$

Where  $T_{al}$  is auto trip time,  
 $T_c$  is trip time by high-capacity rail mode  
 $T_{ff}$  is auto trip time at free-flow speed,  
 $V$  is person trip volume in the corridor by auto, and  
 $\delta, \epsilon$  are model parameters

Equation 1 implies that the door to door auto trip time is equal to the trip time at free-flow speed plus a delay which depends on transit travel time and the person trip volume in the corridor.

In other words, when the highway volume is close to zero, travel time is equal to travel time at free flow speed ( $T = T_{ff}$ ). As the volume increases, the travel time is equal to  $T_{ff}$  plus a delay due to the high volume, but adjusted to the travel time by high capacity transit. That is the high capacity transit alleviates some of the highway trip delay as some trips shift to transit.

Equation 1 is transformed into a linear functional form before the parameters  $\delta$  and  $\epsilon$  can be estimated, the transformed equation will be:

$$U = \delta + \epsilon V_1 \quad (2)$$

Where  $U = \ln [(T_c - T_{ff}) / (T - T_{ff}) - 1]$

Equation 2 is estimated using Ordinary Least Squares regression.

Data The data required for the estimation of the above equations are:

person trip volume on the highway which can be calculated by dividing the traffic volume by the average vehicle occupancy (auto and buses). This data are available through HPMS data base and MPO's traffic data.

free flow trip time is a constant.

high capacity trip time is a constant.

The parameters  $\delta$  and  $\epsilon$  do not have to be re-estimated each year, they are both specific to the corridor and are relatively stable over the years. So periodically, the person trips volume can be inserted into Equation 1 to estimate the door to door travel time by auto.

*Estimating the Corridor Performance in the Absence of transit*

The Model This model represents the concept to quantify the role of transit in congestion management. In the absence of transit, the travel time  $T_a$  is estimated as:

$$T_a = T_{ff} * (1 + A (V^*)^\beta) \quad (3)$$

Where  $T_a$  is the door to door travel time in the absence of transit,

$T_{ff}$  is the trip travel time at free-flow speed,

$V^*$  is the volume of person trips by auto in the absence of transit,

$A$  is a scalar, and  $\beta$  is a parameter.

Equation 3 implies that the door to door travel time in the absence of transit depends on the travel time at free-flow speed and the level of congestion on the road in the absence of transit.

The volume of person trips by auto in the absence of transit, however, depends on several factors:

- The existing auto and bus person trips on the highway.
- The percentage of person transit trips shifting to auto
- The percentage of person transit trips shifting to bus
- The number of additional cars in the highway
- The number of additional buses in the highway

The occupancy per vehicle in the absence of transit The volume of person trips by auto, in the absence of transit, can then be estimated as:

$$V^* = V_1 + \alpha_1 V_c + \alpha_2 V_b \quad (4)$$

Where  $V_1$  is the existing auto volume,

$V_c$  is the transit person trips diverted to cars,

$V_b$  is the transit person trips diverted to buses, and

$\alpha_1, \alpha_2$  are the coefficients that incorporate the passenger car equivalent factor, and the occupancy per vehicle (cars and buses).

The trips diverted to cars and buses depend mainly on the degree of convergence in the corridor. This degree of convergence reflects the transit user behavior and the composition of these users. The transit users can be divided into 3 categories:

Type 1: “Explorers” who are casual switchers and who will divert to Single Occupancy Vehicles in the absence of transit.

Type 2: Commuters with low elasticity of demand with respect to generalized cost and who will divert to use the bus or carpool.

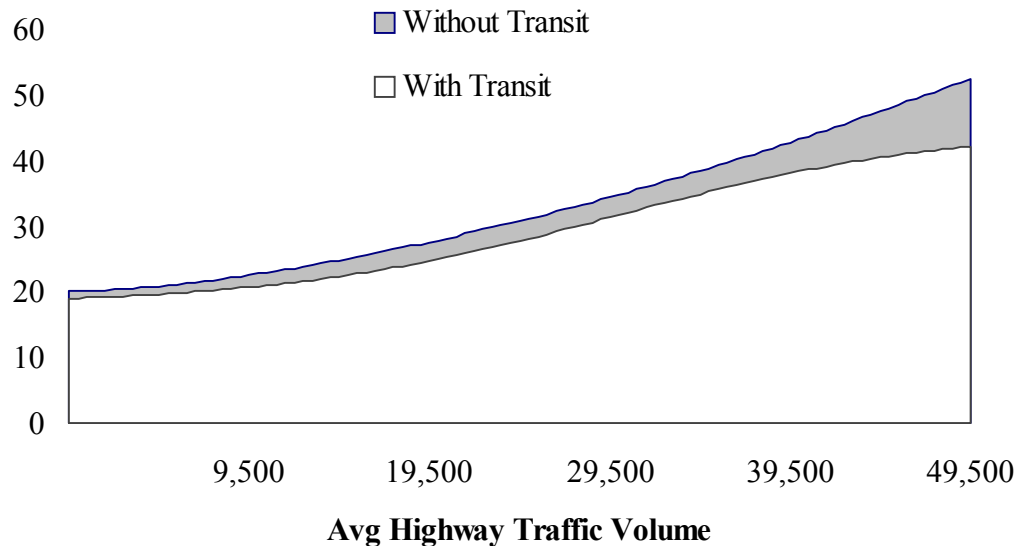
Type 3: Commuters with high elasticity of demand with respect to generalized cost and who will forgoes the trip.

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The higher the degree of convergence (auto and rail door to door travel times are very close), the higher the shift of transit riders to cars and buses. Therefore, higher degree of convergence will lead to higher delay, which translates into higher savings due to transit.

In words, Equation 3 shows that in the absence of transit and in the case of a high degree of convergence, the person trip volume is very high which translates into a high trip time (excessive delay). The relationship between trip time and person trip volume can be expressed as a convex curve (as the volume increases, travel time increases at an increasing rate). The figure below illustrates the relationship between the volume and travel time both in the presence and in the absence of transit.

### Door-to-Door (Minutes)



**Figure A 3.3 Travel Times With and Without Transit**

Data The data required to populate this model consist of:

- Highway person trip volume (used in the previous model)

- Transit ridership data

- Fleet composition (cars and buses percentages out of the total traffic)

- Cars and buses vehicle occupancy

- Passenger car equivalent factor

- Degree of convergence to determine the percentage person trips shifting to cars and buses

- Free-flow travel time which is a constant

Equation 3 is specific to the corridor and do not need to be estimated each year. It will only be necessary to re-estimate them with an updated degree of convergence if a major change is made to the transit level of service or the highway structure.

*Extrapolating Delay Savings Due to Transit*

While the MLC hypothesis proves to be valid during the peak period only, the delay savings due to transit can be estimated during off-peak as well. This metric can be estimated as the vertical difference between the “without transit” curve and the “with transit” curve. That is at a specific person trip volume, the difference in travel times between the two cases can be defined as “the hours of delay saved due to transit”.

The estimated hours of delay savings due to transit are an aggregation of three different user savings: savings by Metro riders (market benefits), savings by highway users (club benefits), and savings by users of parallel highways (spillover benefits).

The market benefits are estimated based on delay saved (which depends on the distance traveled) for each rider within the common segment.

The club benefits are estimated based on the volume on the common segment using origin-destination table and the daily trip distribution.

The spillover benefits are estimated based on the savings per mile, traffic volume, and the distance traveled on segments parallel to the common segment. The spillover benefits are calculated by multiplying the traffic volume with a percentage of the delay savings. This percentage decreases as the distance between the common segment and the parallel highway increases.

*Estimation of Corridor Performance without Re-calibration*

The framework, presented above, provides an MLC-based approach to making repeated measures of transit-induced savings in corridor delay without the need for repeated MLC surveys. The approach rests on the theoretical proposition, that a stable and measurable relationship exists between roadway traffic growth over time and the inter-modal (highway-transit) equilibrium dynamics that give rise to delay savings in a congested corridor. In the absence of major changes in the level of highway supply or transit service in the corridor, this measured relationship, or model, provides a formula-based performance measurement system in lieu of a survey-based approach. In addition to the obvious cost advantages, this approach provides FTA with (i) an efficient means of measuring and comparing transit performance in strategic corridors; and (ii) a consistent performance assessment tool for transfer to MPOs throughout the country.

**Corridor Overview**

The North Hanley--St. Louis corridor is about 13 miles in length. It connects the residential area around North Hanley Station, which is located within ½ mile of the I-170 and I-70 Bypass with the CBD in St. Louis, Missouri. The residential catchment zone is centered around the North Hanley Transit Station. Trip end points within the residential zone are within a 20 minutes drive to the station. The downtown St. Louis, Missouri zone, centered around the Convention Center Light Rail Station, extends for a radius of .5 miles. App. Annex A1 provides maps of the residential and business district zones considered in this study. The North Hanley – Convention Center Metro Link light rail line is part of the 17.5-mile line connecting the Airport to the 5<sup>th</sup> street and Missouri Station in the Illinois side of the City of St. Louis. This line was opened on July, 1993.

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### *Principal Travel Modes*

The “principal travel mode” is defined as the mode used along the common segment of each individual trip. The main transportation modes serving the North Hanley – St. Louis Corridor are automobile and the light rail, Metro Link. The North Hanley - St. Louis line is a 13-mile segment which runs through the University of Missouri campus, the residential area of Forest Park, and the business center around Union Station.

Automobile routes can be broken into three distinct sections:

1. The route between the residential point and the intersection of I-70 and N. Hanley in the transit station area (Access1);
2. The route from the intersection of I-70 and N. Hanley to the I-70 Ramp Leading to Broadway (Common Segment); and
3. The route from the I-70 ramp leading to Broadway and the CBD point (Access2).

For a morning rush hour trip, survey drivers followed Access1 to the common segment. The common segment route originated at the intersection of I-70 and N. Hanley in North Hanley Transit Station area. Drivers followed I-70 East to downtown St. Louis and exited at the Broadway ramp. From the end of the common segment, survey drivers followed Access2 to the downtown points, at which time they parked at the closest parking lot and proceeded on foot to the end point. The evening rush hour trip covered the same progression in the opposite direction.

The routes for the Metro Link light rail mode can also be broken into three distinct sections:

1. The route between the residential point and the N.Hanley Transit Station (Access1);
2. The route between the N.Hanley Transit Station and the Convention Center Station (Common Segment); and
3. The route between the Convention Center Station and the CBD point (Access2).

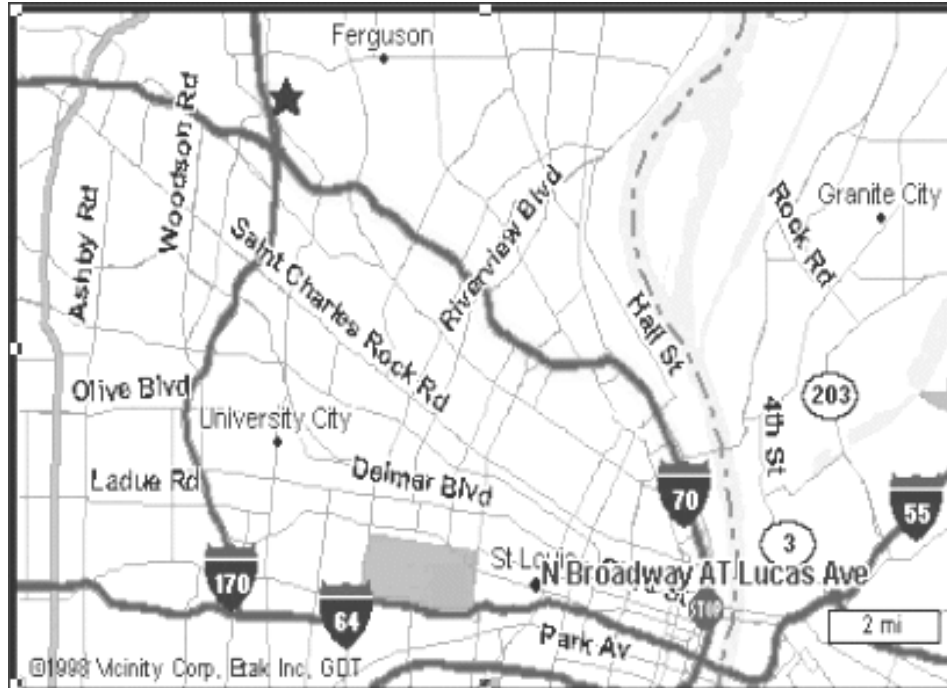
For a morning rush hour trip, survey crews drove Access1 to the N.Hanley Transit Station parking lot and walked from the lot to the Metro Link station. The route taken for the common segment consisted of the light rail trip beginning at the N.Hanley Station and continued to the Convention Center Station. From the end of the common segment, the surveyor walked Access2 to the downtown points. The evening rush hour trip covered the same progression in the opposite direction. On average, trains run every 6 to 7 minutes during peak hours and 10 to 15 minutes during off-peak hours. Table A 3.5 displays some of the principal performance and service characteristics of the corridor.

**Table A 3.5 Performance and Service Characteristics for N.Hanley-St.Louis Corridor**

	Automobile	Light Rail
Number of stops	N/A	13
Number of Streets and Highways	1	N/A
Tolls/Fares for a one way (in dollars)	\$0.00	\$1.25

Figure A 3.4 and Figure A 3.5 show North Hanley--St. Louis corridor routes for the Metro Link and for automobile. In addition to taking daily commuters to work, the light rail system is also heavily used by University of Missouri students and by people going to Kiel Center (sports complex) or Busch Stadium. The line configuration made Metro Link a good multi-purpose transportation mode.

**Figure A 3.4 North Hanley—St. Louis Light Rail Route**



**Figure A 3.5 N. Hanley--St.Louis Corridor Automobile Route**

### **Principal Findings**

This chapter first presents the results from the door-to-door travel survey conducted during the first week of March 1999. The travel survey data are used to derive the inter-modal convergence level in the North Hanley - St. Louis corridor. The chapter then presents the estimation of hours of delay saved due to transit for different user categories.

#### *The Convergence Level*

The starting point to estimate the “without transit” curve is to determine the convergence level based on the key findings from the 1999 door to door travel data.

The door to door travel survey for the N.Hanley-St.Louis Corridor found that:

- Average door-to-door travel times for auto and metro rail are 47.2 minutes by light rail and 36.1 minutes by auto (Table A 3.6).
- Travel time reliability, as represented by the standard deviation of average travel time is 5.3 for light rail mode and 7.3 for the auto mode (Table A 3.6).
- Commuters experienced similar travel times in the morning and in the evening reflecting the similar traffic dynamics of the inbound peak flow and the outbound peak flow in the corridor (Table A 3.7).
- Statistical analysis shows that the mean trip time by auto was at most 14 minutes longer with 95% confidence (Table A 3.8).

- The common segment travel time was greater for the light rail mode than for the transit mode, 27.5 minutes versus 15.7 minutes. The difference of 11.8 minutes between the two modes is due to lower congestion on the highways as more commuters use the light rail. (Table A 3.6).
- Access segment travel times indicate that auto commuters spent on average about the same time outside the common segment as transit commuters. (Table A 3.6).

**Table A 3.6 Results for the N.Hanley-St.Louis Corridor**

	Automobile	Light Rail -MAX
Total Travel Time		
Mean	36.1	47.2
Standard Deviation	7.3	5.3
Access Segment Travel Time		
Mean	20.4	19.7
Standard Deviation	4.5	5.0
Common Segment Travel Time		
Mean	15.7	27.5
Standard Deviation	5.0	1.6
Sample Size	30	30

**Table A 3.7 Comparison of AM and PM Trip Times by Modes**

	Auto	Metro Rail
Inbound AM Average Trip Time	36.3	48.7
Outbound PM Average Trip Time	35.9	47.4

The results in Table A 3.8 indicate that light rail in the defined corridor has drawn door-to-door travel times by highway and light rail to within no more than 14 minutes of one another during congested roadway conditions (with 95 percent statistical confidence).

Although an inter-modal travel time convergence of 11 minutes (difference in mean travel times) is sufficient to yield delay savings to highway users (as compared to the “without rail” case – see below), full convergence would of course yield even greater savings. Why is the convergence level as high as 11 minutes? Stated differently, why is it that, even though door-to-door average peak-period roadway travel time is 14 minutes less than the average door-to-door travel time by light rail, light rail users are not re-exploring the roadway option by enough to “bid-up” roadway times any further?

**Table A 3.8 Statistical Testing of Convergence Hypothesis**

Difference in Mean Travel Times by Mode: (Auto- Metro Rail minutes)	11.1	
Standard Error of the Difference of the Means (minutes):	1.65	
Hypothesis:	Significant at the	Significant at the
“The difference between the mean travel times by modes is at most...”	0.10 Level (90% Confidence)	0.05 Level (95% Confidence)
11 Minutes	NO	NO
12 Minutes	NO	NO
13 Minutes	NO	NO
14 Minutes	YES	NO
15 Minutes	YES	YES

The Mogridge-Lewis framework predicts that non-time related roadway travel costs (i.e, the non-time elements of “generalized cost” such as parking costs, fuel costs and so on) account for the “11 minute wedge.” Light rail users are expected to re-explore the roadway option to the point at which the value of non-time generalized cost factors just equals the value of the travel time advantage offered by road. If non-time costs are moderate to high, travel time convergence will occur at a non-zero time differential between road and rail. Such is the case at-hand. In particular, parking costs in downtown St. Louis are at or above the national average. Parking capacity is low as a matter of land-use and transportation planning policy, which means that the time-related costs of finding parking and gaining walk-access to the final destination thereafter are higher than the national average. As well, low parking capacity drives the money cost of parking above the national average. The Mogridge-Lewis framework predicts convergence at a non-zero travel time differential in such circumstances. It also predicts convergence at a travel time differential that lies above the national average differential for corridors in convergence. Both predictions are borne out in the Portland case presented here.

Like the Gateway-Portland corridor case study, the design of expanded park-and-ride facilities in response to capacity constraints at existing stations will materially influence the extent and direction of inter-modal exploration. Designs that minimize auto-to-platform walking times (such as vertical structures rather than ground-level expansion) encourages auto users to explore light rail and discourages light rail users from exploring auto. This in-turn helps maximize light-rail’s convergence-related benefits. St. Louis’ current parking structure in stations such as North Hanley Station (“horizontal” rather than “vertical” park-and-ride expansion) is not consistent with the maximization of transit’s performance as a “regulator” of multi-modal corridor performance.

*Methodology Application on N. Hanley-St. Louis Corridor*

Data HLB collected HPMS data, local arterials traffic data, and light rail ridership data from Bi-State Development Agency (the local transit authority), East-West Gateway Coordinating Council (the local MPO), and the Missouri Department of Transportation.

In addition door to door travel time survey was conducted to derive the corridor degree of convergence. HLB estimated the model, described in Section 1 using the obtained data.

Model Equation 1 is estimated as follows:

$$T_{a1} = (45 - 18) / (1 + e^{-(3.28 + 0.00011(V))}) + 18 \quad (1)$$

Similarly, Equation 2 is estimated based on auto travel volume, transit ridership data, and convergence level estimate from the survey.

$$T_{a2} = 18 * (1 + 5.4E-08 (V^*)^{1.59}) \quad (2)$$

The auto traffic volume in the absence of transit is determined by adding the auto volume in the presence of transit to the generated auto trips by transit riders. The generated results are based on:

- 31% of person transit trips will be forgone (determined by the corridor convergence level).
- The average vehicle occupancy (HOV and non-HOV) is 1.2 for cars and 40 for buses.
- Car trips will make about 90% of trips.

#### *Benefit Estimation*

To estimate the travel time saving (TTS) attributed to transit, the current traffic volume is inserted into Equation 1 and 2. An auto volume of 37,500 results into:

$$T_{a1} = 36.2, \quad T_{a2} = 40.09, \text{ and } TTS = T_{a2} - T_{a1} = 3.89$$

That is on average, in N.Hanley-St.Louis corridor, transit saves about 3.89 minutes per auto trip (17 seconds per mile) during the peak period

Once the average travel time saving per vehicle is estimated, the savings are weighted to reflect the congestion level at each time of the day.

The benefits are calculated for three user groups:

1. Benefits to highway users (Club), these are the hours saved by the common segment user of the N.Hanley-St. Louis corridor (see Table A 3.9).
2. Benefits to Transit users (Market), these are the hours saved by the users of transit between N.Hanley TC and Convention Center Station (see Table A 3.10).
3. Benefits to the highway network users within the corridor (spillover), these are the hours saved by users of parallel and adjacent highways to the common segment within the corridor (see Table A 3.11).

Table A 3.9 through Table A 3.11 show the benefits estimate by user category.

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**Table A 3.9 Club Benefits**

	Distance (miles)	Avg Daily Traffic Volume	Daily Savings (hours)
Common Segment			
I-70	11	61,167	1,826
Access Segment (on average)	2.5	37,000	251
Total	13.50		2,077

**Table A 3.10 Market Benefits**

Station	West-bound Trips	East-bound Trips	Daily Savings (hours)
N. Hanley	312	2,635	114.64
UMSL North	111	829	34.74
UMSL South	239	1,233	51.53
St. Charles Rock Road	482	1,207	55.85
Wellston	386	869	39.06
Delmar Blvd.	729	1,487	64.65
Forest Park	664	1,413	56.56
Central West End	1,907	1,539	87.13
Grand Avenue	1,680	1,080	64.42
Union Station	1,539	1,294	60.61
Kiel Center	828	385	21.23
Bush Stadium	603	355	14.91
8 <sup>th</sup> and Pine	1,468	918	37.13
Convention Center	1,595	1,509	42.26
Total			745

**Table A 3.11 Spillover Benefits**

Highways in the corridor	Distance (miles)	AADT	Daily Savings (hours)
W. Florissant Blvd.	5.95	19,000	276.07
Natural Bridge	7	22,800	389.75
Saint Louis Blvd.	3.85	12,650	92.50
Dr. Martin Luther King Blvd.	7	28,640	462.38
Delmar Blvd.	4.2	18,000	143.59
Page Street	5.95	16,040	181.27
College Lane/Lindell Boulevard	3.15	18,760	112.24
Forest Park Avenue	3.85	22,480	164.39
I-64/I-170	13.3	62,019	1,454.80
Total			3,277

**Table A 3.12 Summary of Benefits**

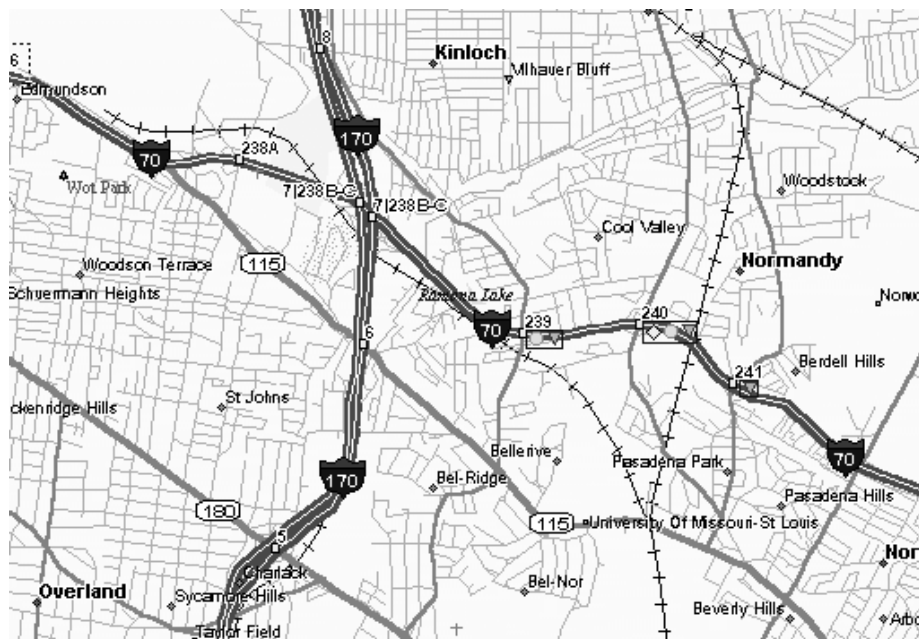
Benefit Category	Daily Savings		Yearly Savings
	In Hours	In Dollars	In Dollars
Market	701	\$ 10,519	\$ 2,629,762
Club	2,077	\$ 31,150	\$ 7,787,481
Spillover	3,277	\$ 49,155	\$ 12,288,780
Total	6,055	\$ 90,824	\$ 22,706,023

Table A 3.12 shows that the 1998 delay saving attributed to transit on the N.Hanley-St. Louis corridor is estimated at about \$22.7 million. This can be translated to \$1.7 million per rail mile.

The methodology implies that in the absence of major infrastructure improvements or strong growth in volume of traffic the performance metric will remain stable. So, it should suffice to gather corridor travel time—degree of convergence—once every several years. In the case of major infrastructure improvement or a change in the transit service, however, door to door travel time data should be collected to estimate an accurate performance metric.

# The North Hanley Light Rail Corridor Serving St. Louis

### Annex A 3.1 Views of the North Hanley Light Rail Corridor



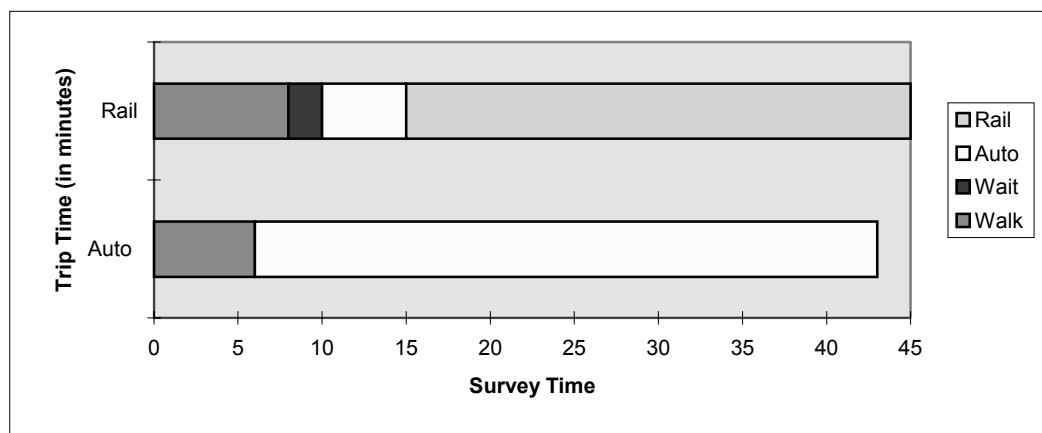
### Figure A 3.6 Map of the Residential District



**Figure A 3.7 Map of the Central Business District**

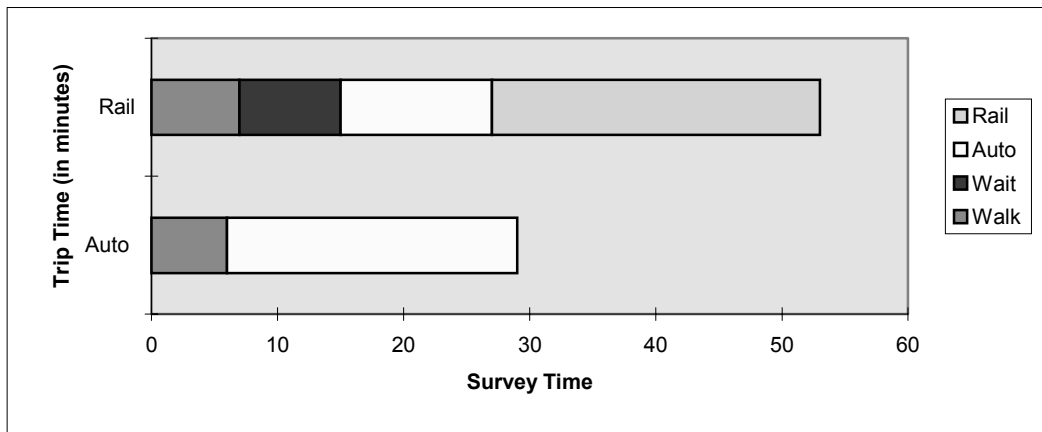
## Annex A 3.2 The Survey Findings by Route

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE B-2:</b> <b>Prospect &amp; Hern Road - Delmar &amp; 10th Street</b>		
	<b>SURVEY TYPE</b>	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	43	45
In Common Segment	20	30
Outside Common Segment	17	5
Wait Time	0	2
Walk Time	6	8
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	18.1	20.0
In Common Segment	33.0	24.0
Outside Common Segment	7.1	36.0

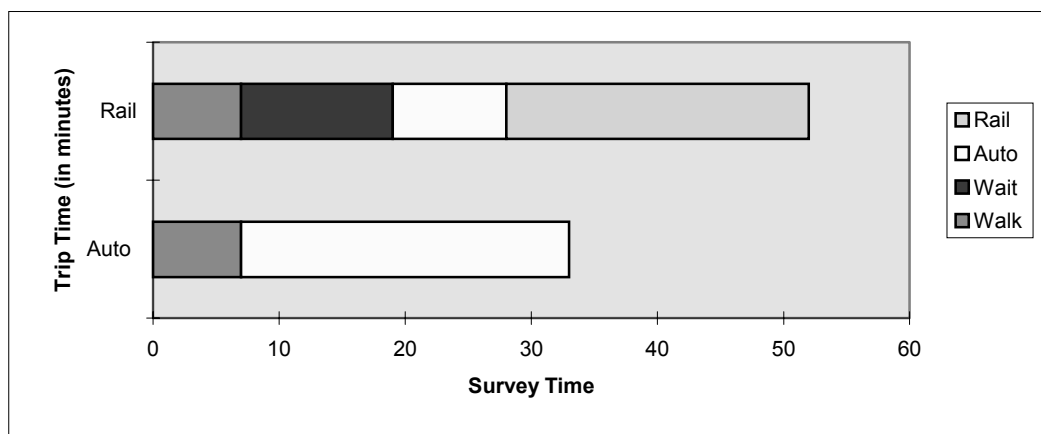


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE D-4:</b> <b>Albin &amp; N Hanley Road - Carr &amp; 10th Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	29	53
In Common Segment	11	26
Outside Common Segment	12	12
Wait Time	0	8
Walk Time	6	7
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	26.9	17.0
In Common Segment	60.0	27.7
Outside Common Segment	10.0	15.0

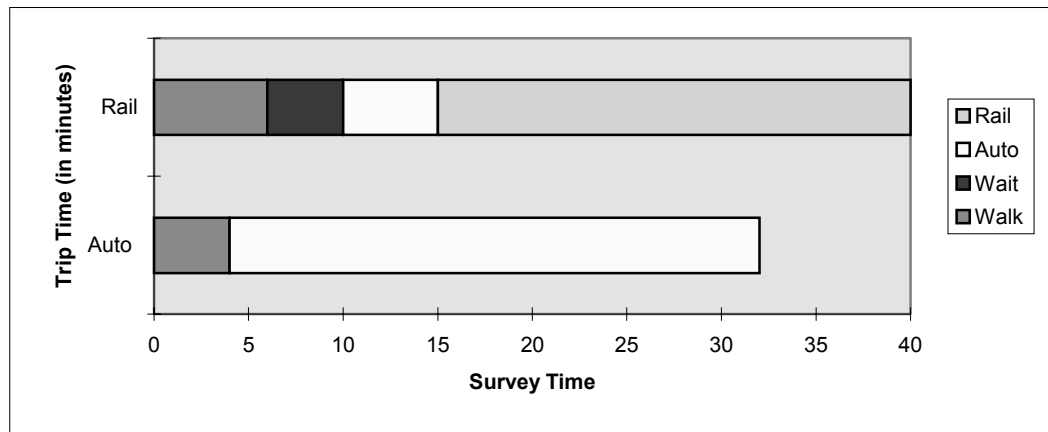


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE E-5:</b> <b>Monroe &amp; N Hanley Road - Washington &amp; 11th Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	33	52
In Common Segment	13	24
Outside Common Segment	13	9
Wait Time	0	12
Walk Time	7	7
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	23.6	17.3
In Common Segment	50.8	30.0
Outside Common Segment	9.2	20.0

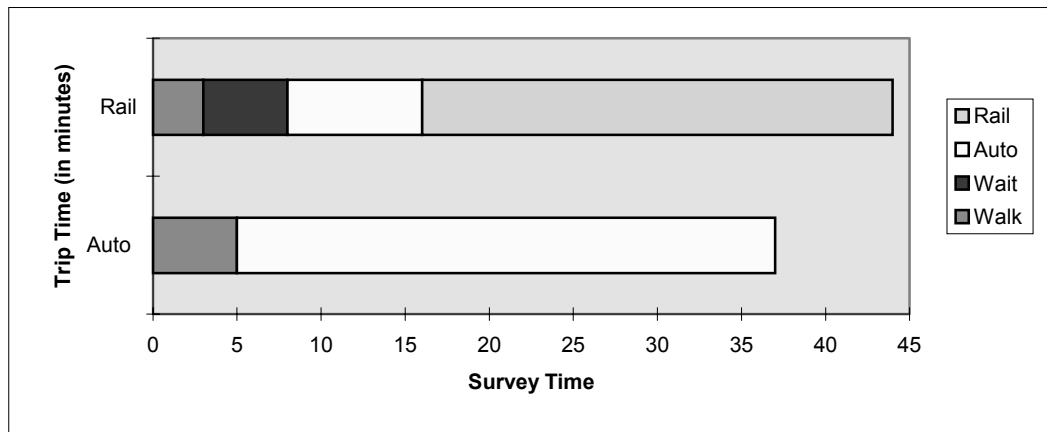


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE C-3:</b> <b>Randolph &amp; S Florissant Road - Martin Luther King &amp; 10th Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	32	40
In Common Segment	12	25
Outside Common Segment	16	5
Wait Time	0	4
Walk Time	4	6
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	24.4	22.5
In Common Segment	55.0	28.8
Outside Common Segment	7.5	36.0

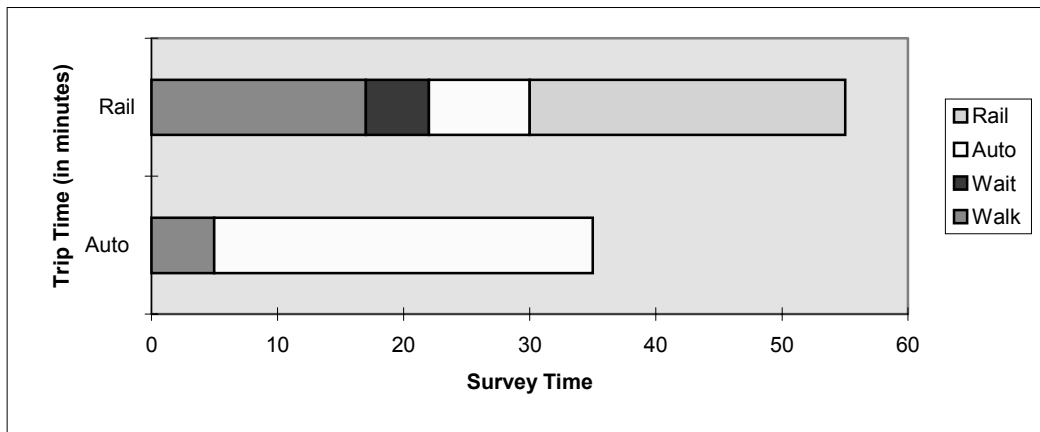


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 1-A:</b> <b>Broadway &amp; Lucas Street - Monroe &amp; Scudder Road</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	37	44
In Common Segment	27	28
Outside Common Segment	5	8
Wait Time	0	5
Walk Time	5	3
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	21.1	20.5
In Common Segment	24.4	25.7
Outside Common Segment	24.0	22.5

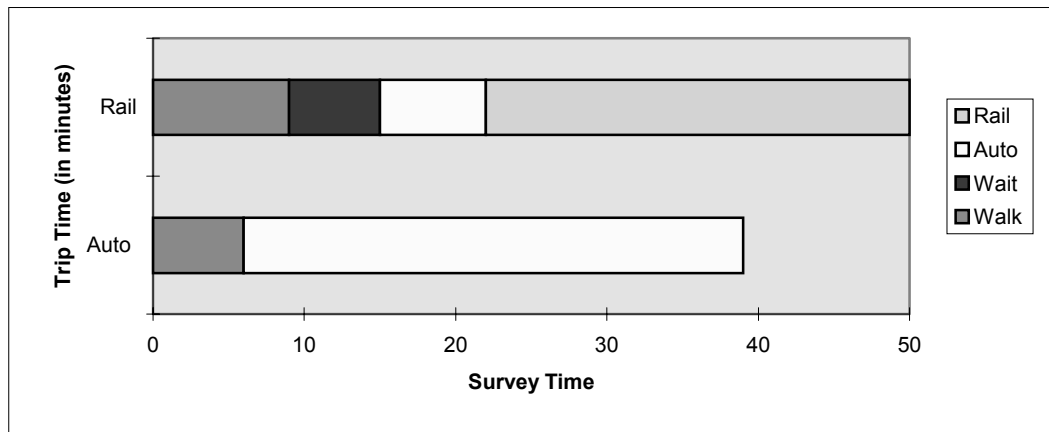


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 4-D:</b> <b>Carr &amp; 10th Street - Albin &amp; N Hanley Road</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	35	55
In Common Segment	15	25
Outside Common Segment	15	8
Wait Time	0	5
Walk Time	5	17
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	22.3	16.4
In Common Segment	44.0	28.8
Outside Common Segment	8.0	22.5

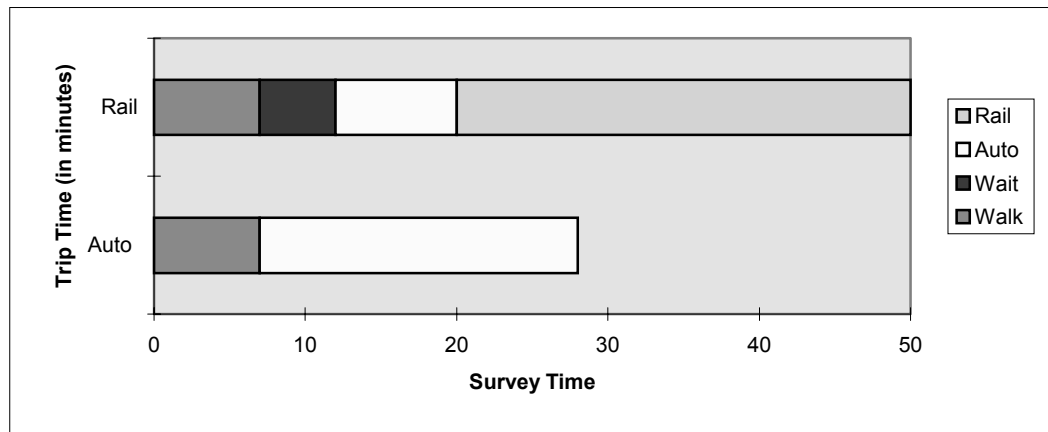


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 1-B:</b> <b>Broadway &amp; Lucas Street - Prospect &amp; Hern Road</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	39	50
In Common Segment	19	28
Outside Common Segment	14	7
Wait Time	0	6
Walk Time	6	9
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	20.0	18.0
In Common Segment	34.7	25.7
Outside Common Segment	8.6	25.7

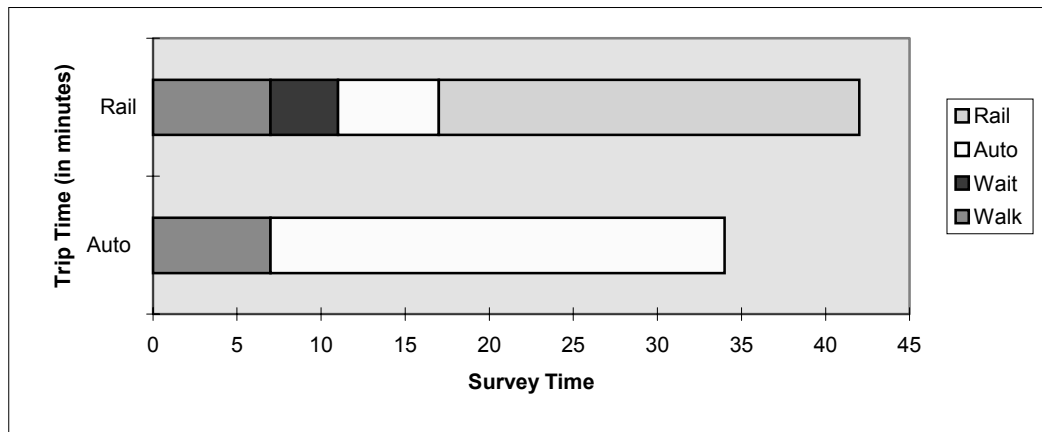


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 5-E:</b> <b>Washington &amp; 11th Street - Monroe &amp; N.Hanley Road</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	28	50
In Common Segment	10	30
Outside Common Segment	11	8
Wait Time	0	5
Walk Time	7	7
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	27.9	18.0
In Common Segment	66.0	24.0
Outside Common Segment	10.9	22.5

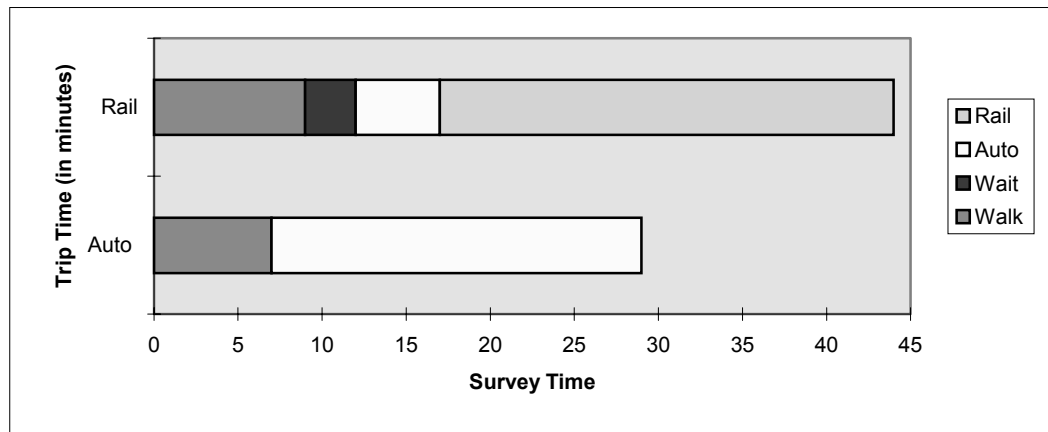


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 3-C:</b> <b>Martin Luther King &amp; 10th Street - Randolph &amp; S.Florissant Road</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	34	42
In Common Segment	13	25
Outside Common Segment	14	6
Wait Time	0	4
Walk Time	7	7
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	22.9	21.4
In Common Segment	50.8	28.8
Outside Common Segment	8.6	30.0

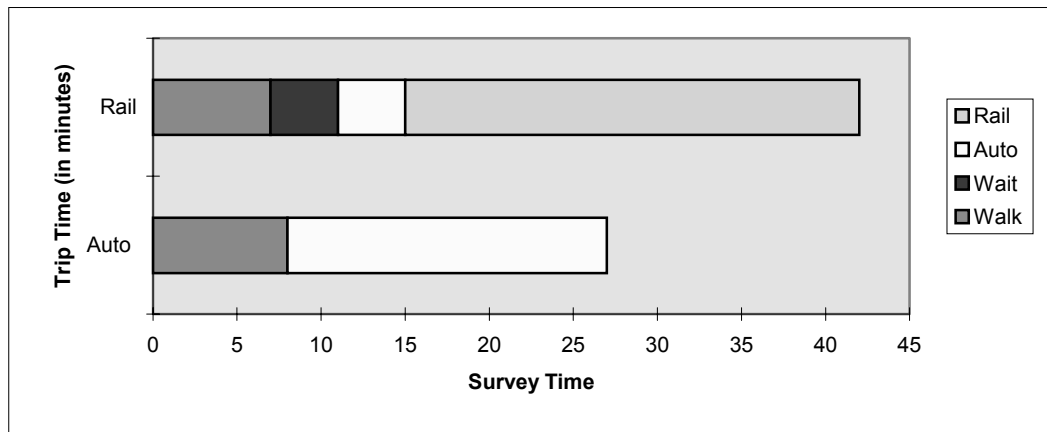


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE D-3:</b> <b>Albin &amp; N.Hanley Road - Martin Luther King &amp; 10th Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	29	44
In Common Segment	10	27
Outside Common Segment	12	5
Wait Time	0	3
Walk Time	7	9
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	26.9	20.5
In Common Segment	66.0	26.7
Outside Common Segment	10.0	36.0

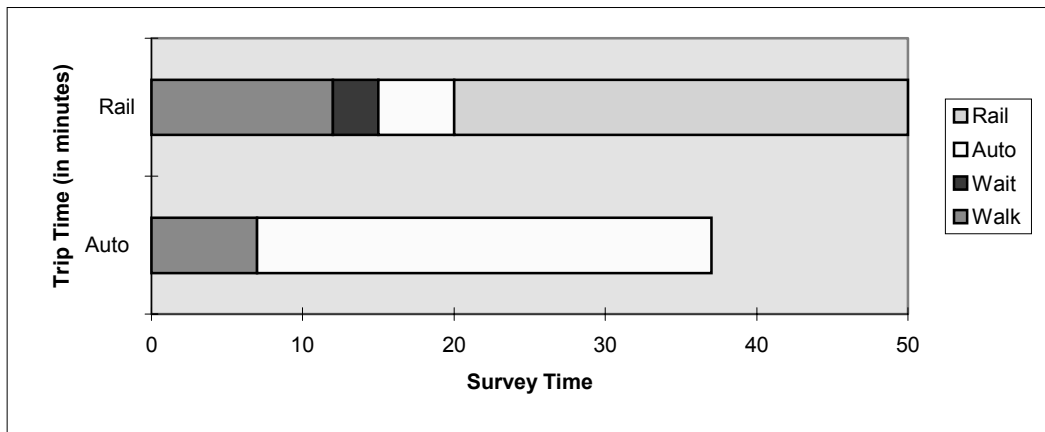


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE B-1:</b> <b>Prospect &amp; Hern Road - Broadway &amp; Lucas Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	27	42
In Common Segment	14	27
Outside Common Segment	5	4
Wait Time	0	4
Walk Time	8	7
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	28.9	21.4
In Common Segment	47.1	26.7
Outside Common Segment	24.0	45.0

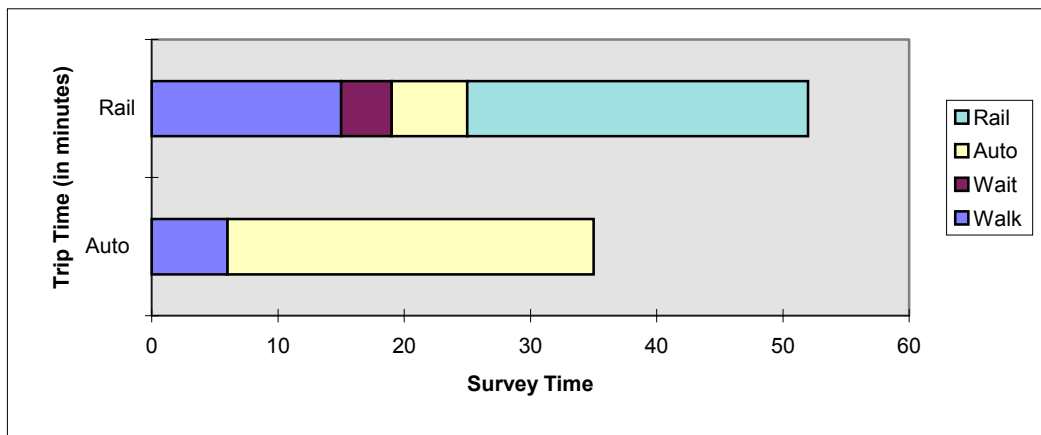


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<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE E-4:</b> <b>Monroe &amp; N.Hanley Road - Carr &amp; 10th Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	37	50
In Common Segment	15	30
Outside Common Segment	15	5
Wait Time	0	3
Walk Time	7	12
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	21.1	18.0
In Common Segment	44.0	24.0
Outside Common Segment	8.0	36.0

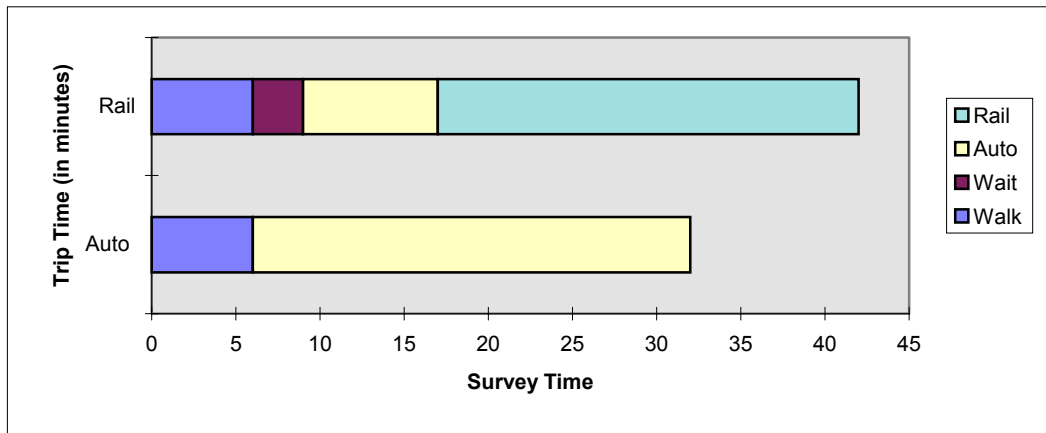


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE C-2:</b> <b>Randolph &amp; S.Florissant Road - Delmar &amp; 10th Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	35	52
In Common Segment	15	27
Outside Common Segment	14	6
Wait Time	0	4
Walk Time	6	15
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	22.3	17.3
In Common Segment	44.0	26.7
Outside Common Segment	8.6	30.0

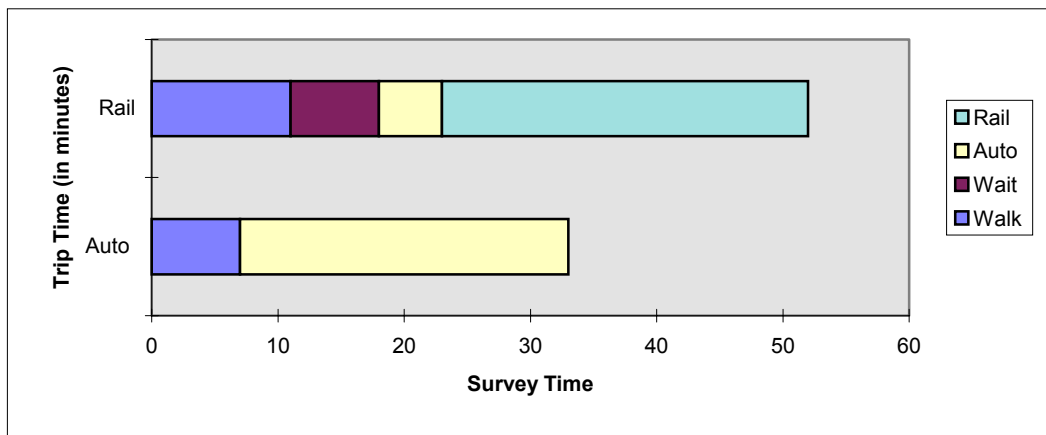


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE F-5:</b> <b>Midland &amp; Brown Road - Washington &amp; 11th Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	32	42
In Common Segment	11	25
Outside Common Segment	15	8
Wait Time	0	3
Walk Time	6	6
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	24.4	21.4
In Common Segment	60.0	28.8
Outside Common Segment	8.0	22.5

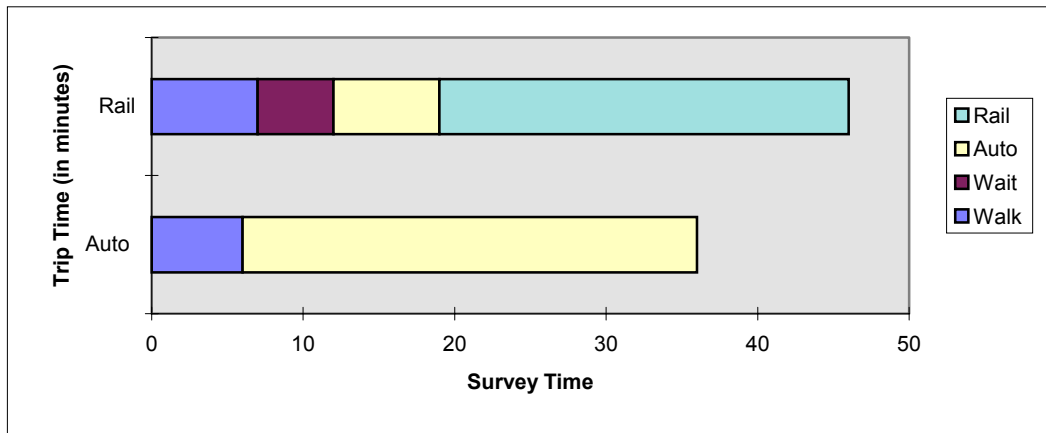


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 3-D:</b> <b>Martin Luther King &amp; 10th Street - Albin &amp; N Hanley Road</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	33	52
In Common Segment	14	29
Outside Common Segment	12	5
Wait Time	0	7
Walk Time	7	11
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	23.6	17.3
In Common Segment	47.1	24.8
Outside Common Segment	10.0	36.0

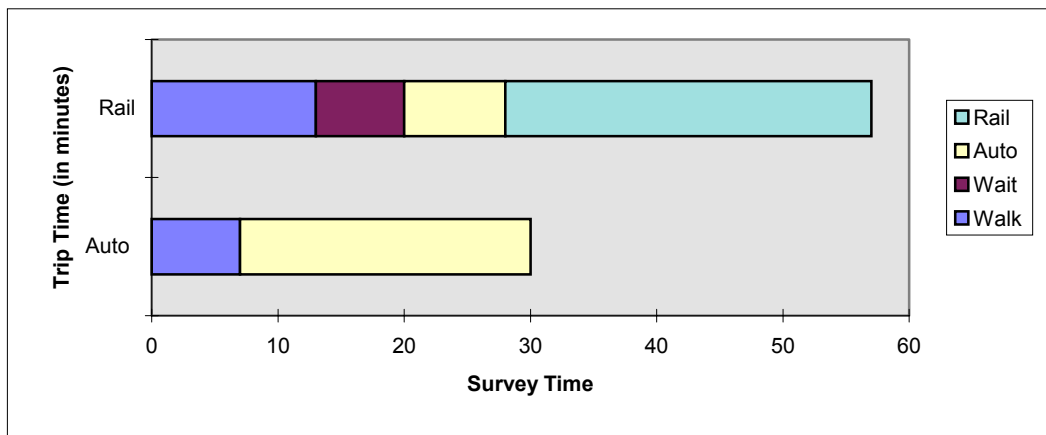


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 2-B:</b> <b>Delmar &amp; 10th Street - Prospect &amp; Hern Road</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	36	46
In Common Segment	16	27
Outside Common Segment	14	7
Wait Time	0	5
Walk Time	6	7
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	21.7	19.6
In Common Segment	41.3	26.7
Outside Common Segment	8.6	25.7

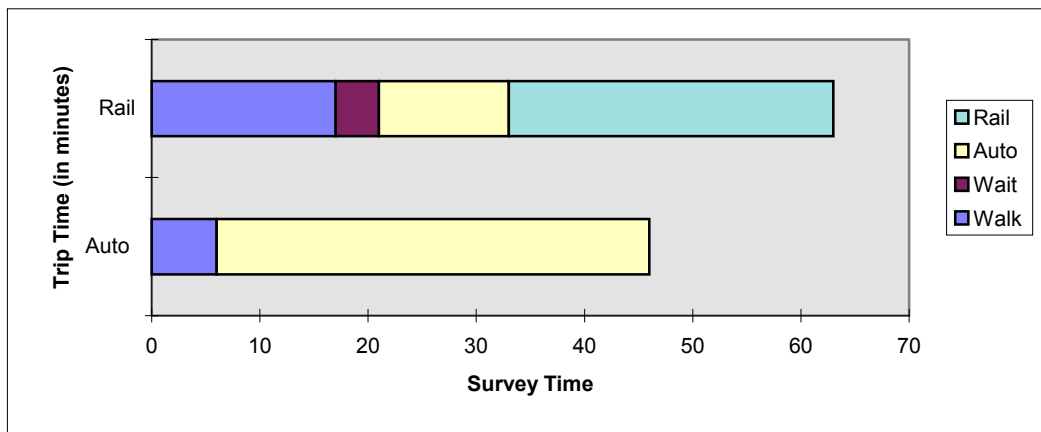


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 4-E:</b> <b>Carr &amp; 10th Street - Monroe &amp; N.Hanley Road</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	30	57
In Common Segment	15	29
Outside Common Segment	8	8
Wait Time	0	7
Walk Time	7	13
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	26.0	15.8
In Common Segment	44.0	24.8
Outside Common Segment	15.0	22.5

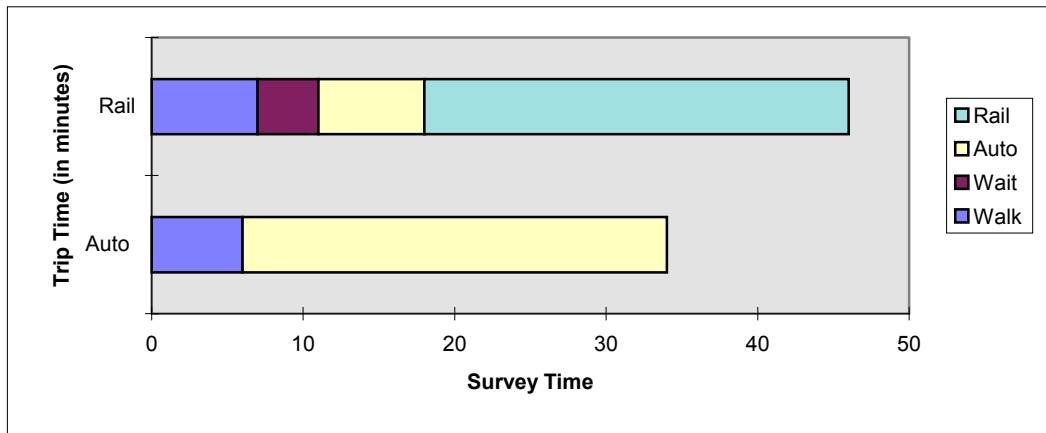


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 2-C:</b> <b>Delmar &amp; 10th Street - Randolph &amp; S.Florissant Road</b>		
	<b>SURVEY TYPE</b>	
<b>TIME (minutes)</b>	Auto	Light Rail
Trip	46	63
In Common Segment	24	30
Outside Common Segment	16	12
Wait Time	0	4
Walk Time	6	17
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	17.0	14.3
In Common Segment	27.5	24.0
Outside Common Segment	7.5	15.0

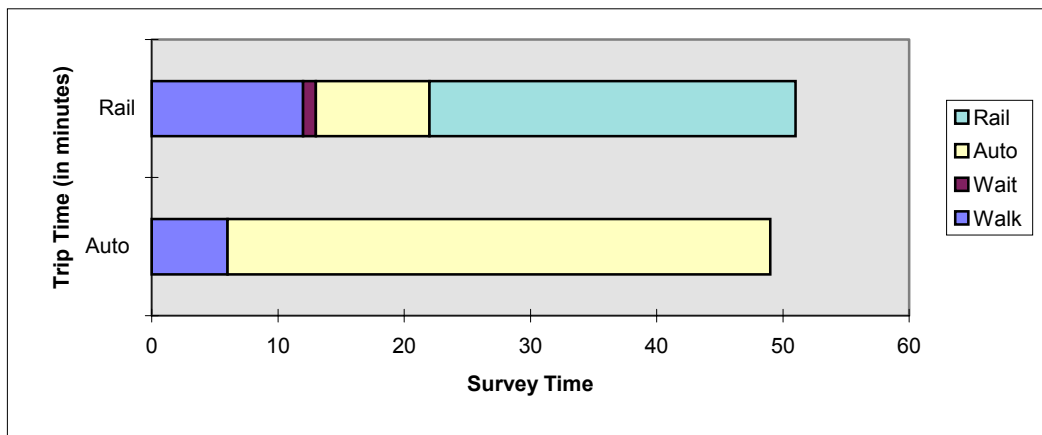


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE 5-F:</b> <b>Washington &amp; 11th Street - Midland &amp; Brown Road</b>		
	<b>SURVEY TYPE</b>	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	34	46
In Common Segment	12	28
Outside Common Segment	16	7
Wait Time	0	4
Walk Time	6	7
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	22.9	19.6
In Common Segment	55.0	25.7
Outside Common Segment	7.5	25.7

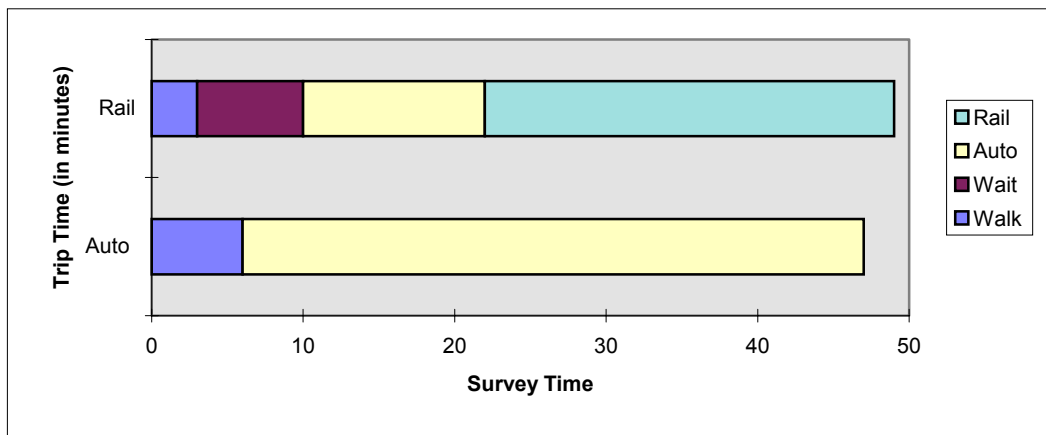


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE F-6:</b> <b>Midland &amp; Brown Road - Locust &amp; 11th Street</b>		
	<b>SURVEY TYPE</b>	
<b>TIME (minutes)</b>	Auto	Light Rail
Trip	49	51
In Common Segment	20	29
Outside Common Segment	23	9
Wait Time	0	1
Walk Time	6	12
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	15.9	17.6
In Common Segment	33.0	24.8
Outside Common Segment	5.2	20.0

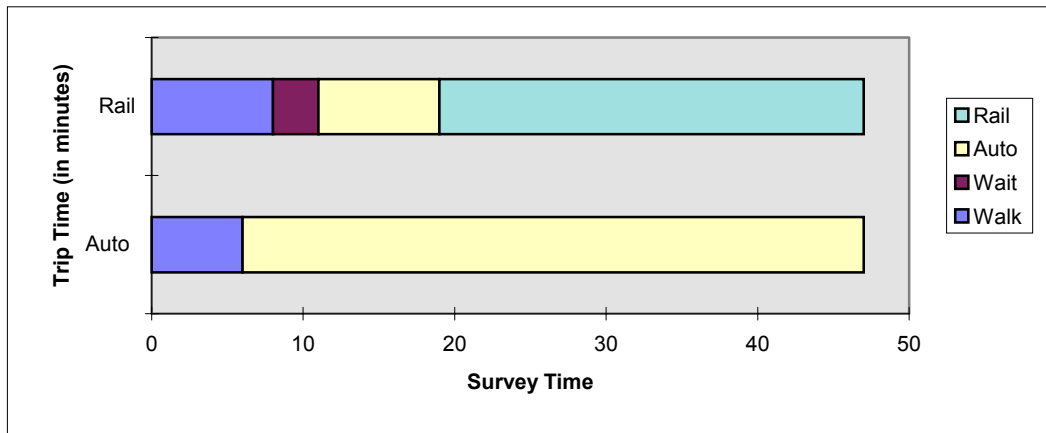


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE G-7:</b> <b>Boswell &amp; North Road - Pine &amp; 10th Street</b>		
	<b>SURVEY TYPE</b>	
<b>TIME (minutes)</b>	Auto	Light Rail
Trip	47	49
In Common Segment	20	27
Outside Common Segment	21	12
Wait Time	0	7
Walk Time	6	3
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	16.6	18.4
In Common Segment	33.0	26.7
Outside Common Segment	5.7	15.0

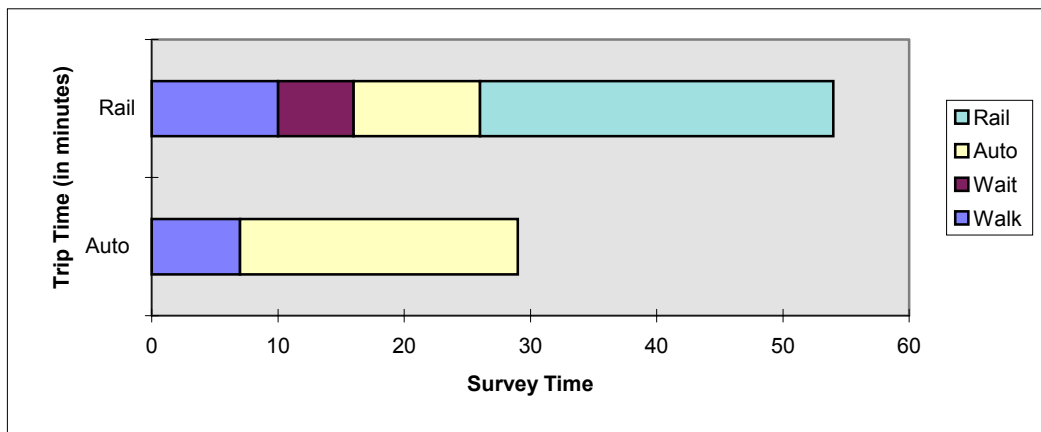


The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE H-8:</b> <b>Boswell &amp; Harold Road - Broadway &amp; Olive Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	47	47
In Common Segment	20	28
Outside Common Segment	21	8
Wait Time	0	3
Walk Time	6	8
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	16.6	19.1
In Common Segment	33.0	25.7
Outside Common Segment	5.7	22.5

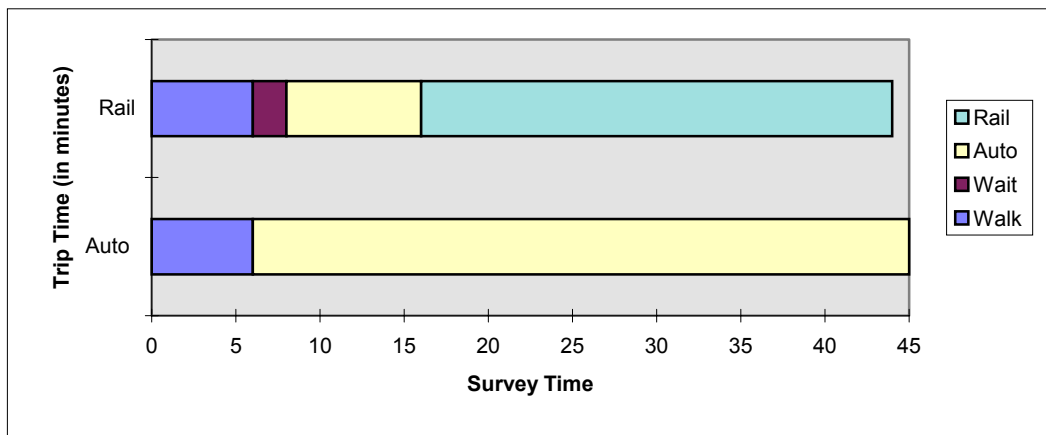


<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE I-9:</b> <b>Lucas and Hunt &amp; Route 115 - Locust &amp; 4th Street</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	29	54
In Common Segment	11	28
Outside Common Segment	11	10
Wait Time	0	6
Walk Time	7	10
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	26.9	16.7
In Common Segment	60.0	25.7
Outside Common Segment	10.9	18.0



The North Hanley Light Rail Corridor Serving St. Louis

<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE J-10:</b> <b>Clearview &amp; Audrain - Saint Charles &amp; Broadway</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	45	44
In Common Segment	16	28
Outside Common Segment	23	8
Wait Time	0	2
Walk Time	6	6
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	17.3	20.5
In Common Segment	41.3	25.7
Outside Common Segment	5.2	22.5



<b>CORRIDOR: North Hanley - St. Louis</b> <b>SUMMARY TABLE FOR</b> <b>ROUTE A-1:</b> <b>Monroe &amp; Scudder Road - Broadway &amp; Lucas Avenue</b>		
	SURVEY TYPE	
	Auto	Light Rail
<b>TIME (minutes)</b>		
Trip	24	45
In Common Segment	11	28
Outside Common Segment	6	7
Wait Time	0	7
Walk Time	7	3
<b>DISTANCE (miles)</b>		
Route Distance	13.0	15.0
Common Segment Distance	11.0	12.0
<b>SPEED (mph)</b>		
Trip	32.5	20.0
In Common Segment	60.0	25.7
Outside Common Segment	20.0	25.7

